DOE/NASA CONTRACTOR REPORT

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DEVELOPMENT AND FABRICATION OF A CONCENTRATING SOLAR COLLECTOR SUBSYSTEM (Third and Fourth Quarterly Reports)

Prepared by

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302 Nichols Drive
Hutchins, Texas 75141

Under Contract NAS8-32251 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

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This work was done under the technical management of Mr. John Caudle, George C. Marshall Space Flight Center, Alabama.

16. ABSTRACT

This report contains the Third and Fourth Quarterly Reports covering the period from April 1, 1977, through September 30, 1977. These reports cover the finalization of designs, fabrication of the new lens, receiver, and tracking box and a review of the contract status.

Cost information has been removed.

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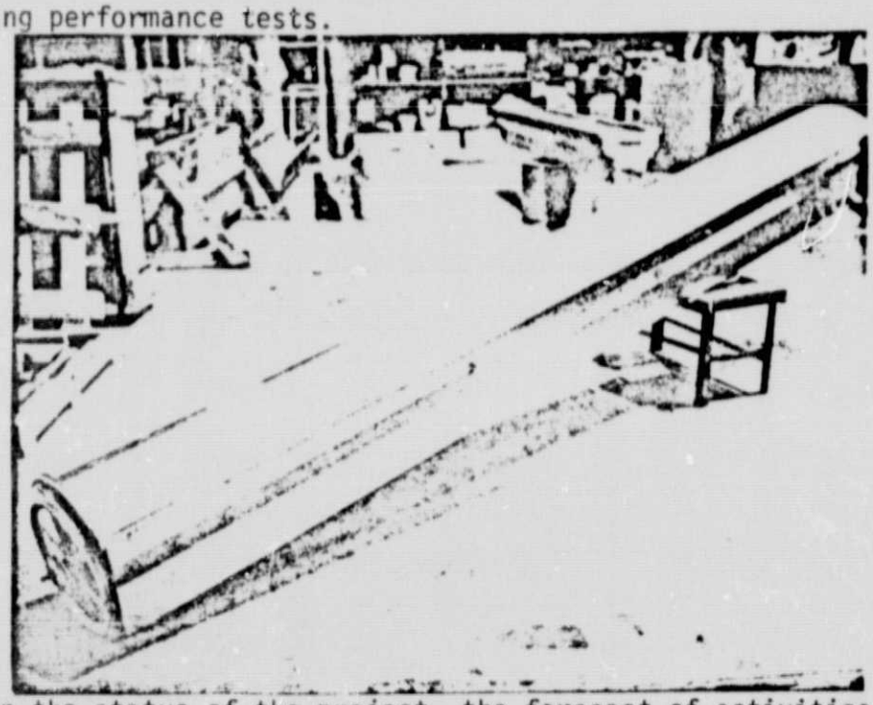
I. SUMMARY

This third Quarterly Report summarizes the progress of work in all areas, and in particular, the finalization of designs and first prototype drawings and fabrications of the new lens, receiver, and tracking box.

During this Quarter, the first samples of the new lens began arriving from the extruders and the iterative process of refining the lens began. The absorber design was settled on, and significant refinements were made in the attitude controller and overall system reliability.

Shown below is a photograph of one of the first prototype collectors now undergoing performance tests.



Based on the status of the project, the forecast of activities and probable sequence of events needed to complete the project are given.

II. CONTRACT

The status of all technical aspects of the work are given in Section 3. The contractual status of the work is shown in the following section. The contract is approximately 80% complete. Baseline conditions have already surpassed the best performance of the first generation.

2.1 Changes

During the past quarter, Mr. Carl Taylor was replaced by Ms. Merle Thomas.

Mr. Worley of the Dallas DCASR office reviewed our contract, as did Mr. William McMasters.

No significant modifications were instigated during this Quarter.

2.2 Value of Work

The worth of the work performed to date is summarized in Table 1. The extent of the work performed is summarized on the Development Plan Schedule presented in Section 3. Description of technical performance appears in Section 4.

2.3 Variances

Based on communications with MSFC a Delta of approximately 3 weeks has been agreed on to allow attitude controller subcontract work to be finalized.

Table 1

#	TASK	SCHEDULE # WEEKS
1.	Concentrating Element	-3
2.	Receiver Tube Element	-4
3.	Casing Element	+4
4.	Manifold Element	+8
5.	Attitude Controller	-3
6.	Collector Assembly	0
7.	Merchandising Plan (including installation instructions)	-1
8.	Delivery to MSFC	0
9.	TOTAL	0

Cost information has been removed.

III. SCHEDULES

3.1 Development Plan

The Development Plan Schedule is given in Figure 2.

Lens development is documented in the 9th and 10th monthly reports. Preceding at the rate of 2 die changes a day, Doctor Robert Waller will go to the extruders this next quarter to personally participate in the fabrication of an improved lens. Lens work should be on target in two weeks.

The attitude controller is undergoing extensive modification to increase reliability, tracking accuracy and extend the life of the mechanism. During the Quarter, the previous P.C. board supplier, P.T.L., was dismissed, and Reich Associates of Plano, Texas were brought on board.

Other major components are on target for integration into the prototype.

3.2 Verification Plan

The Prototype Design Review package, its accompanying RID's and the responses, contain the most current reviews of each element of the Verification Plan.

IV. TECHNICAL PERFORMANCE

The collector prototype now surpass the best models of the first generation in many respects.

4.1 Work Accomplished

During the quarter, the final design of the lens, the receiver and the attitude controller have been checked and confirmed.

Lens - The first lens began to arrive from the extruder. Rapid progress outlined in monthly report #9 has been made. Focusing accuracy is being checked with two new devices, a visual silhouette of the focusing rays, and an intensity profile. Lens geometric one giving results similiar to those of the best first generation lenses.

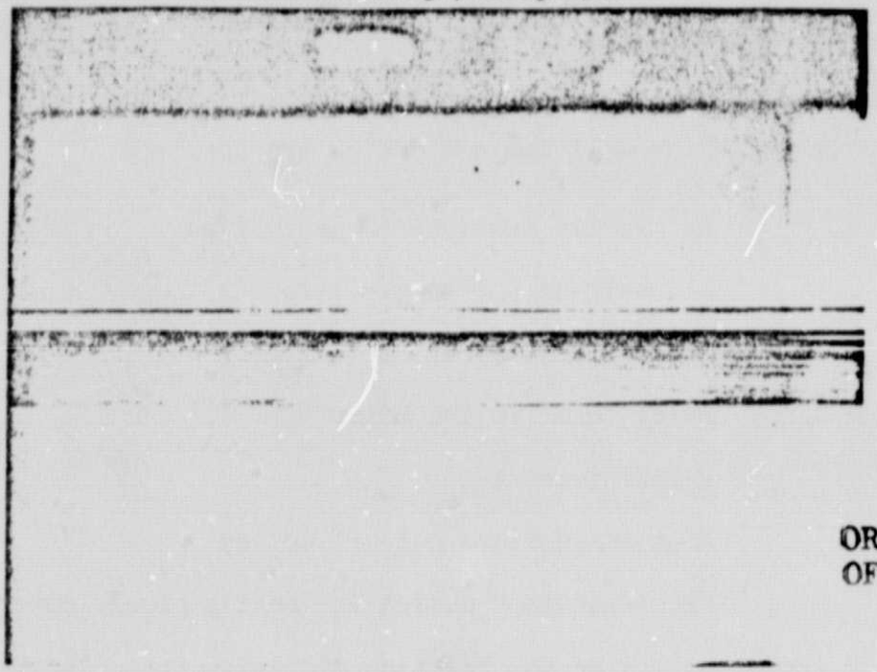
Attitude Controller - A new subcontractor, Reich Associates has joined in the development effort. The P.C. board has undergone several changes. Features of the new design are these:

- Potted for atmospheric protection
- Low voltage for longer life
- Fully U.L. approval
- Relay to drive the motor
- 2 year guarantee
- High temperature cut-off option
- "Positraction" option for partly cloudy condition

The mechanics of the tracking mechanism are undergoing extensive improvements to reduce friction in the drive mechanism and increase "tracking box" life on large systems. These improvements are outlined in monthly report #9 and are included in the Prototype Design Review.

Insulation - New, low binder insulation has been tried and discarded in favor of JMRA-22, a standard, high temperature fiberglass material.

Receiver - After extensive testing of several alternatives an atmospheric receiver with a glass jacket has been found to be the most durable and best performing per cost / efficiency. The atmospheric receiver offers higher operating temperatures, ease of field replacement, and a lower cost per unit output than do the various evacuated tubes available. Please see the following photograph.



4.2 Forecast

Upon successful and satisfactory completion of all elements of the Prototype Design Review, the contractor will commence the fabrication and assembly of complete prototype assemblies.

Key to integrating the prototype will be these steps:

- Completion of the lens. Estimated time from date Dr. Waller goes to the extruder - 3 to 4 weeks.

- Completion of the attitude controller. Estimated time to check out - 3 weeks.

After the first complete prototypes are tested in a month, the steps towards the first article review should proceed right on schedule, extensive work done during the Prototype Design stage will insure the overall performance of the system during the First Article Review stage.

4.3 Problems

Problems have been encountered in several areas. Key examples and their solutions are the following:

- Tracking box - the attitude controller supplied with the first generation system often could not handle the load requirements of large arrays (20 or more collectors per tracker). Problems have arisen in field installation, and several remedial, corrective expeditions have been launched from the factory to refit field failures. Benefitting from this experience the 407 team have undertaken a complete redesign of the tracking mechanics and electronics. The problem has been severe enough to warrant a delta in the PDR for the attitude controller of three weeks.

- Lens - Due to the long iterative process involved in developing the lens, it has become necessary to send Dr. Waller to the extruders to personally supervise the work. Continuing effort will enable the team to get back on schedule with the lens and complete the finishing touches at least a month before the First Article Review.

4.4 Data Package

Please refer to the Data Package and RID's connected with the Prototype Design Review.

I. Summary

This report, including the 15th monthly report, contain a review of the contract status, an update on changes to the contract and a revised development schedule.

II. Contract

Please see Schedule A, the current Work Plan, for a graphic presentation of the schedule of work left on the contract.

The completion date of the contract has been moved to 4/30/78 per Supplemental Agreement 6.

In accordance to Supplemental Agreement 5, the Subsystem Performance Specification was altered slightly to reflect more realistic test sites and conditions.

The fixed total price of this contract is not affected by the changes.

The contract, having completed its 15th month in operation of a total 19 months, is 80% complete, with the tracking box, prototype housing and structure, and final lens design now in the fabrication stage.

III. Schedules

Please see Schedule A, the Development Plan. The Verification Matrix and Plan will be ready by January 12.

IV. Technical Performance

A. Work Accomplished

Work accomplished during the period is described in the attached reports. Development work on the lens has included the polishing and chrome plating of the topside of the die, and the underside of the central convex section. Test samples delivered in December indicate good progress. Please see lens photograph.

Low voltage tracking electronics are fully tested, and now in production. Encapsulated P.C. boards and other features are now standard production items.

Two new tracking boxes have been built. Please see the accompanying photographs.

The prototype housing and structure are in fabrication.

B. Forecast of Activities

Major activities to complete tasks are the following:

B. Forecast of Activities (cont'd)

Lens: Final iteration on several key facets (prisms) still improvable. Polishing and chrome plating of bottom die. One month.

Absorber Tube: Finalization of size, geometry and wall thickness. Tests of optimum seasonal focal length. Two months.

Housing: Final assembly. One month.

Trackers: Tests and U.L. approval. One month.

Structure: Assembly. One month.

Array: Assembly and test. Two months.

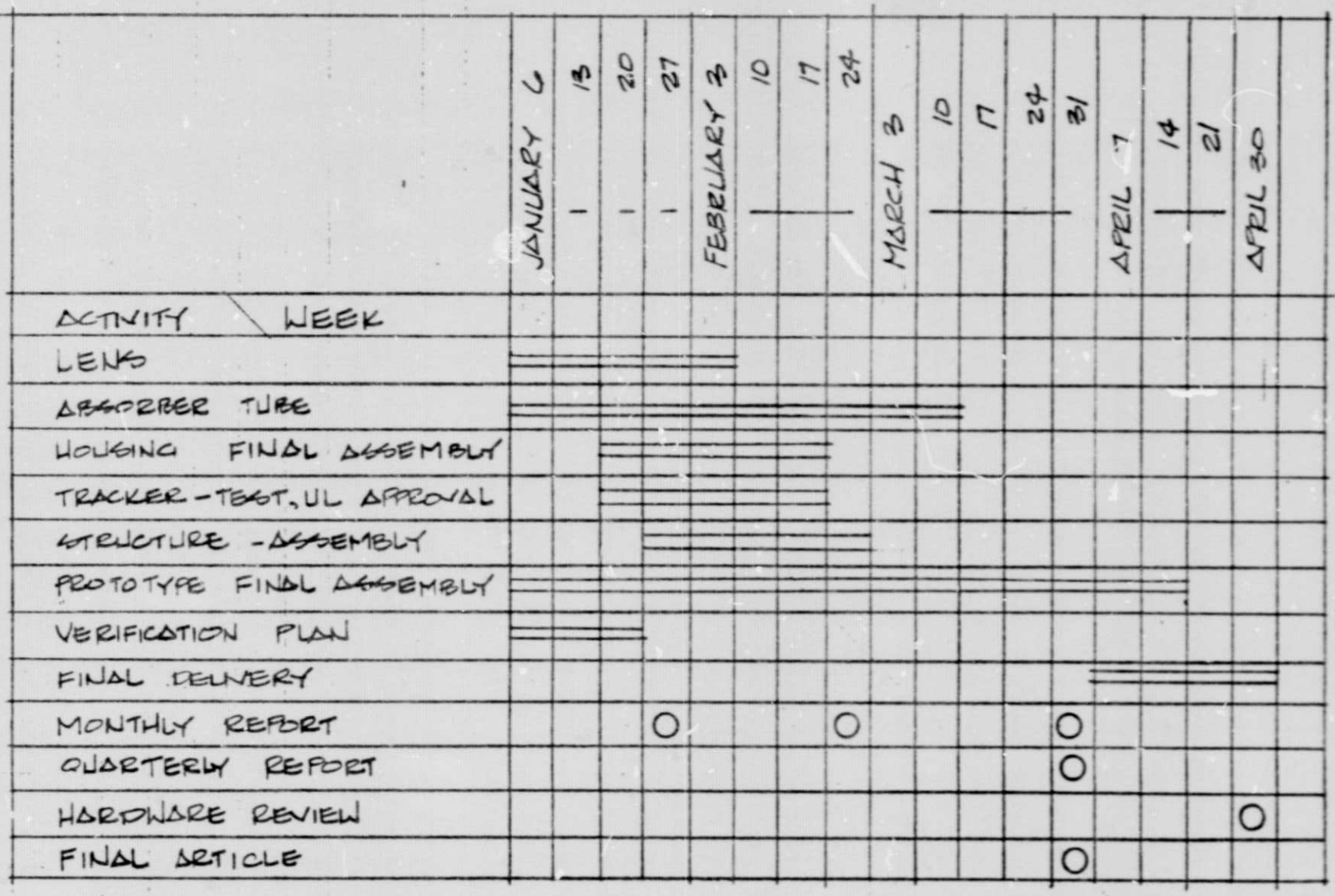
Prototype: Final assembly.

Verification Plan: Due 1/20/78

C. Problem Areas

Due to untimely holiday schedules, vacations, and sickness among key personnel, prototype fabrication and test has been delayed. Now, at full strength, the team should be able to go ahead without delay in this area.

The absorber tube will be made of a heavier gauge copper tubing flattened to a narrower cross sectional profile than the current production model. Tests, further analyses and fabrication have been slow, but will be of primary emphasis during January.



NORTHRUP INC
HUTCHINS, TEXAS

DEVELOPEMENT PLAN
SCHEDULE A
NAS-8-32251

WORK ACCOMPLISHED: Product Development, Fabrication, and Modification

Progress in the total development of the product has been realized in terms of actual prototype fabrication. Particular emphasis has been placed on the tracking control mechanism and the assembly of the modular framing system components. Modifications, both in terms of shop and production techniques, and engineering development have been implemented as the fabrication process has evolved.

The tracking mechanism prototype is being assembled and tested at the component, shop sub-assembly, and final assembly levels. Beginning with the electrical components of the tracking controls, the printed circuit board is being tested and modified to address the compatibility of advances made in sensing devices now being developed. Maintenance issues (realized in response to various review item discrepancy reports) have resulted in research and evaluation of the drive motor in terms of both testing and surveys of service records of motors already installed. Alternative products that can be integrated into the current tracking device are being considered. Less technical items such as the assembly of the actual electrical component box, wire lengths and gages, and installation techniques are being finalized. In considering the mechanical drive components, improved means of transmitting loads from the ball nut assembly to the aluminum rods are being examined in review of easing assembly limitations and eventual maintenance. The development of the total tracking control box has required assembly of a new test facility with specific test requirements. It is now in the final design stages.

Regarding UL certification, all applicable reports, petitions, and descriptions are being filed and answered in order to maintain a dialoque and define the standards acceptable to verification. Also under current consideration are the effects of corrosion upon external and internal components.

Development of the framing system has been completed and is now in the fabrication and modification stage. Production limitations have resulted in the necessity of the redesign of several components, however no revisions have been required beyond the "detail" stage and the total design concept of the system has remained virtually intact. Excessive lead times for certain commercially uncommon commodities have influenced the slow rate of the fabrication and the assembly of the prototype. Continued development of the lens has also evolved to the point assembly can soon be expected, with integration into the housing in January.

WORK ACCOMPLISHED: (cont'd)

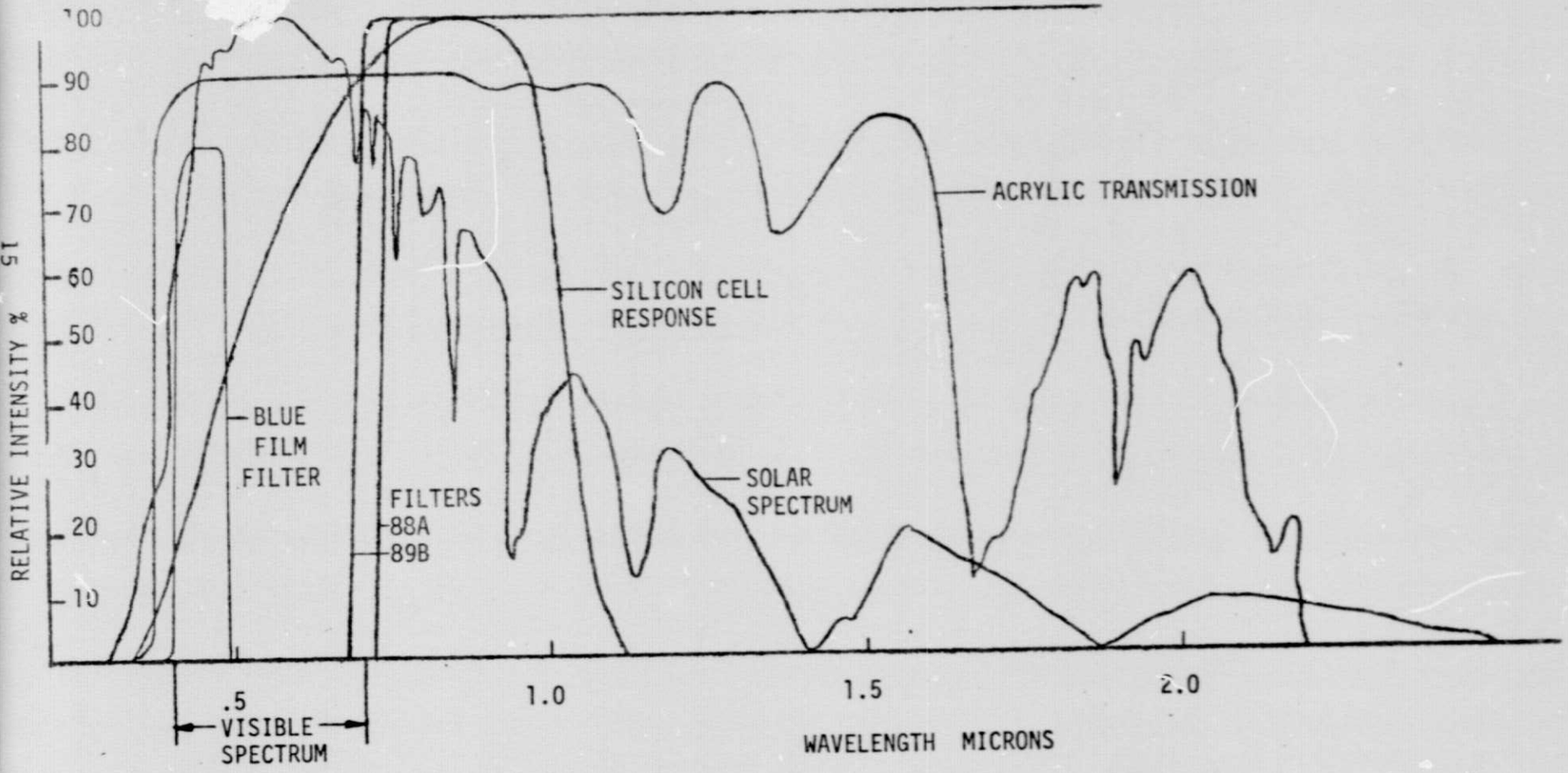
Seasonal constraints (weather and holidays) have retarded prototype fabrication.

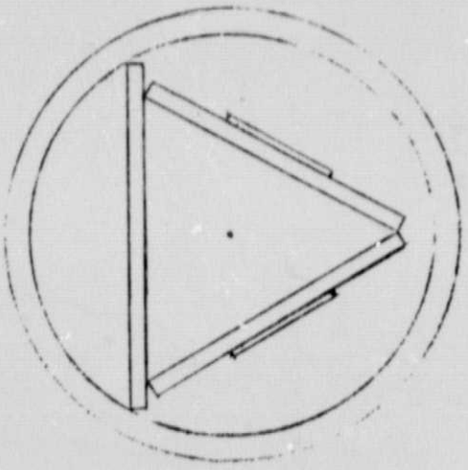
TRACKING

There have been two basic problems with tracking. The first and more important one occurs when the beginning of a day is overcast, then clears in the afternoon. In the past it has sometimes resulted in the sensor and collectors remaining in the east facing position after the sun appeared. This happens because the light rays enter the sensor housing past the acceptance angle of the sensor configuration. The problem has been easily rectified by mounting the solar cells in a triangular configuration which greatly increases the acceptance angle. The mounting scheme is shown in Figure 1.

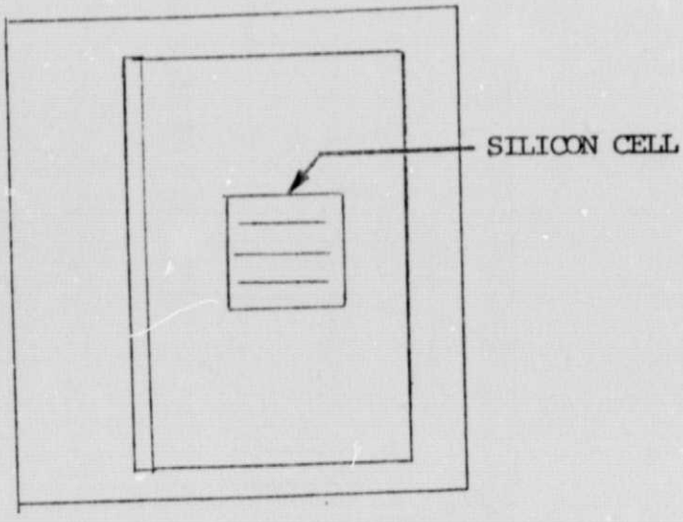
Another problem that existed is "cloud tracking". The sensor will "hunt" nearby clouds rather than the sun on partly cloudy days. Although this normally represents a small portion of tracking time and small loss in performance, it is something that can be improved upon, if not totally corrected. Various optical filters placed over the silicon cells have been shown to dramatically reduce the amount of cloud searching. Tracking data samples are included on the following pages. Three filters that have produced good results are Kodak filters 88A and 89B, and a blue filter produced by the Martin Llumar Company. On the next page the transmission curve of each is shown in relation to the solar spectrum, silicon cell response and acrylic transmission.

Stability is an important consideration when choosing a filter for use in the field. Kodak filter 89B has been subjected to the following test conditions: Two weeks' exposure to daylight in a south window, twenty-four hours' exposure to a "Fade-Ometer", and two weeks' exposure at two feet from a 1000-watt tungsten lamp. After these tests the filter shows no greater change in its transmittance curve than 5%. Unfortunately, no long term data is available nor is any stability data available on 88A. On the


100
90
80
70
60
50
40
30
20
10
RELATIVE INTENSITY %
ACRYLIC TRANSMISSION
SILICON CELL RESPONSE
SOLAR SPECTRUM
BLUE FILM FILTER
FILTERS 88A 89B
.5
VISIBLE SPECTRUM
1.0
1.5
2.0
WAVELENGTH MICRONS



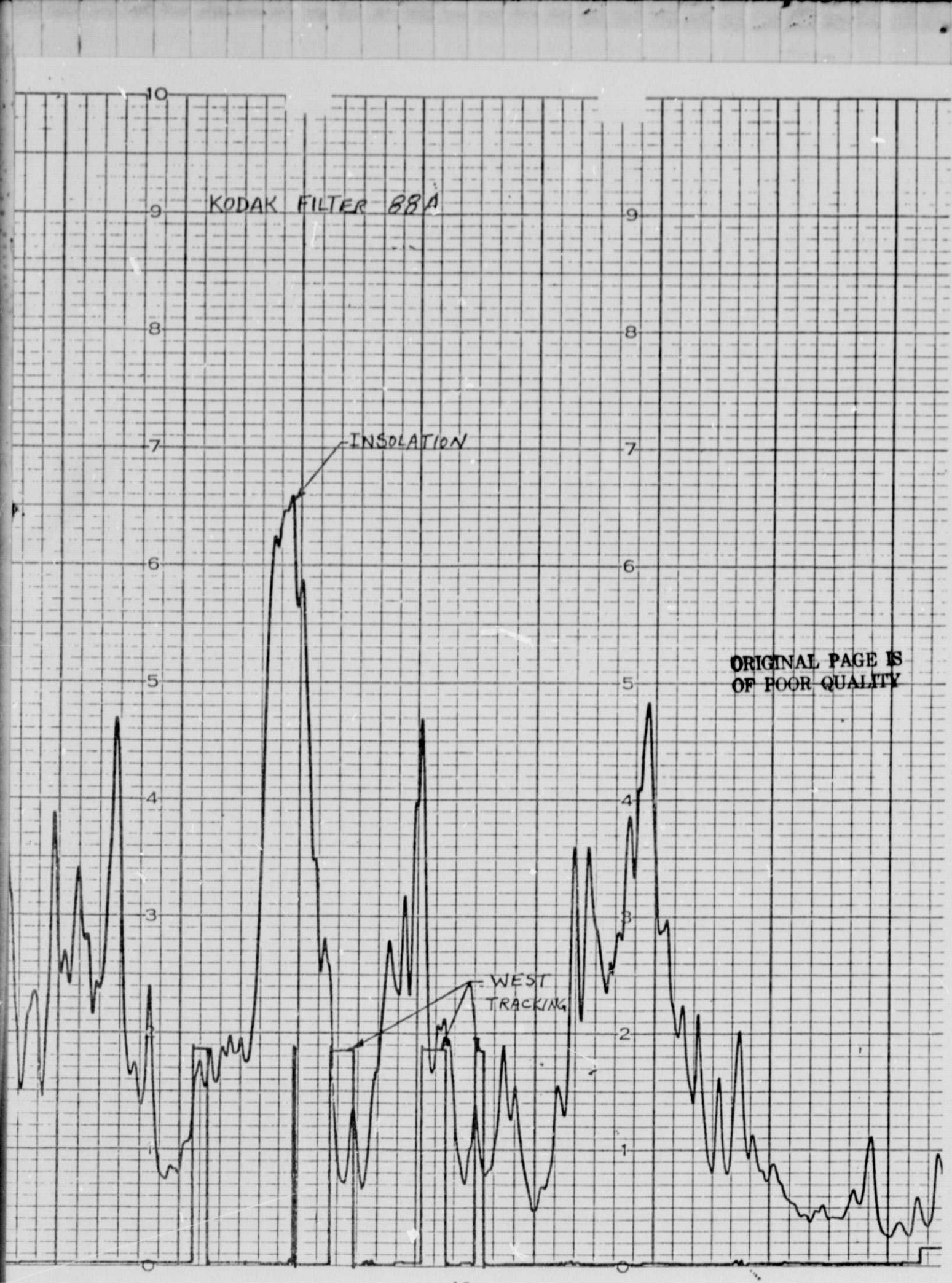
ACRYLIC HOUSING



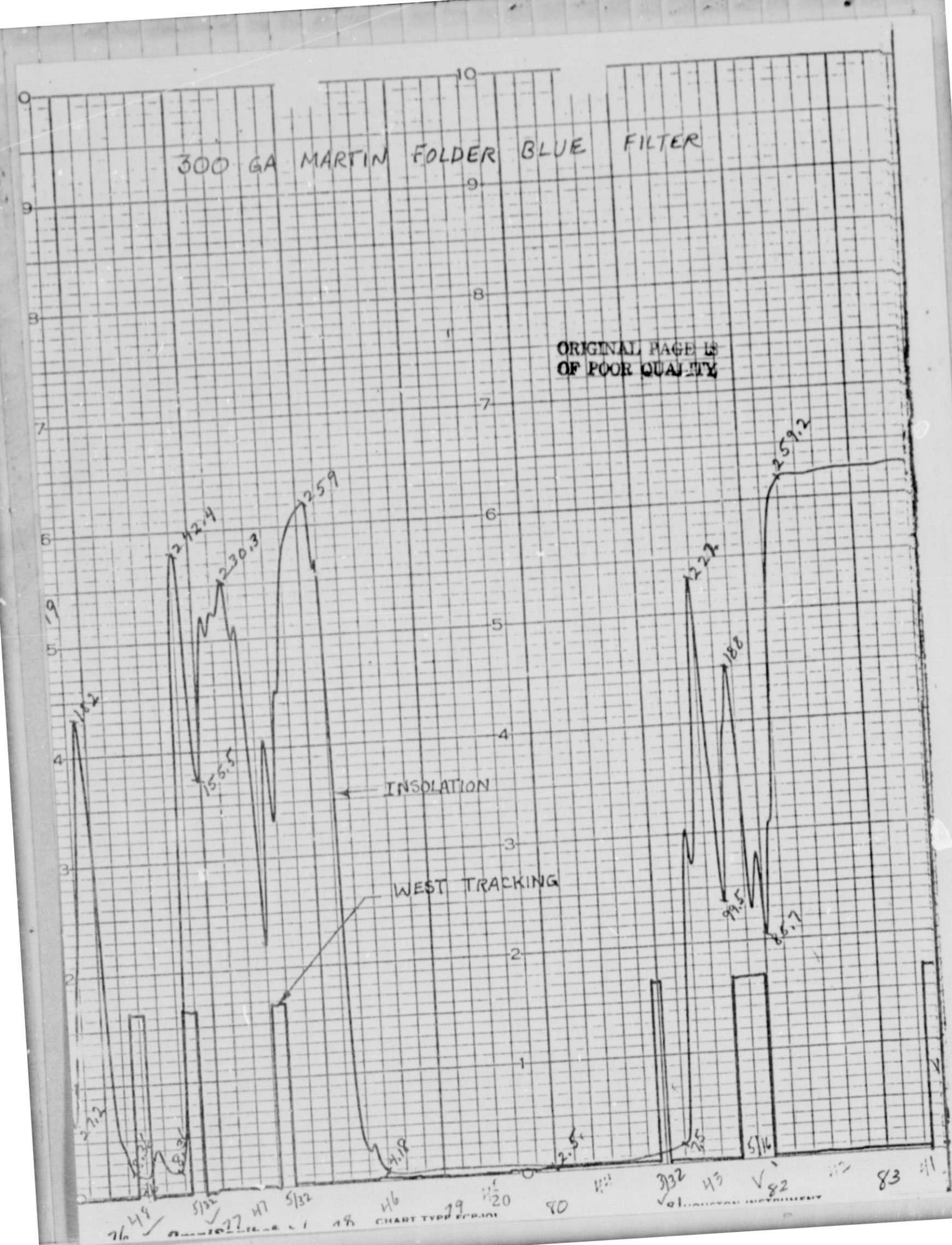
SENSOR HOUSING

FIGURE 1

otherhand, Martin filters have been shown to withstand 15 years of outdoor field testing with very little degradation. Because of this reason, attempts will be made to finalize a sensor assembly utilizing this filter. The update factor as well as the threshold level of the control board will be adjusted as required.




KODAK FILTER 89 B
INSOLATION
I = 238
BTU/HR-FT²
WEST TRACKING
10
9
8
7
6
5
4
3
2
1
0


300 GA MARTIN FOLDER BLUE FILTER
ORIGINAL PAGE IS
OF POOR QUALITY
INSOLATION
WEST TRACKING
162
242.4
230.3
259
155.5
259.2
222
188
99.5
86.7
27.2
4.8
2.5

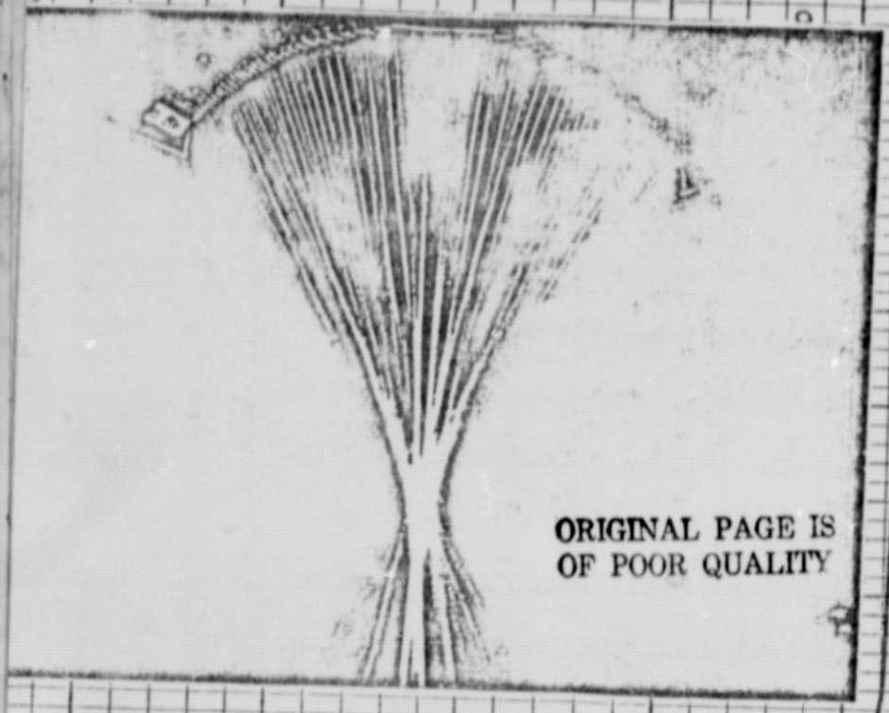
LENS

A photograph of the latest lens and a profile curve of the light concentration are included with this report. Efforts will continue to further improve the extrusion die before final polishing and chroming. The light concentration has been improving per each sample and should keep doing so.

Theoretical efficiencies have been generated based on the light concentration profiles and a flattened, black chrome plated tube similar to the one used on the present Northrup collector. The y - intercept point on the efficiency curve is approximated by multiplying the amount of energy incident on the absorber tube by the absorptivity. The slope of the curve can then be computed by basing heat loss on previous efficiency tests of a collector using the flattened tube. The amount of energy incident on the tube is found from the light concentration profile. This technique can be employed because the photo cell used to generate the profile curves has an output that is linear with intensity. A theoretical efficiency curve is included with this report. Note that a straight line is shown indicating linear heat losses. The efficiency curve for the present Northrup collector has been shown to be linear which gives validity to using a straight line approximation.

Twelve degree incident angle approximates solar alignment at February 21, and August 21. Direct normal incident angle can be better.

12 1/4" @ 12° INCIDENCE



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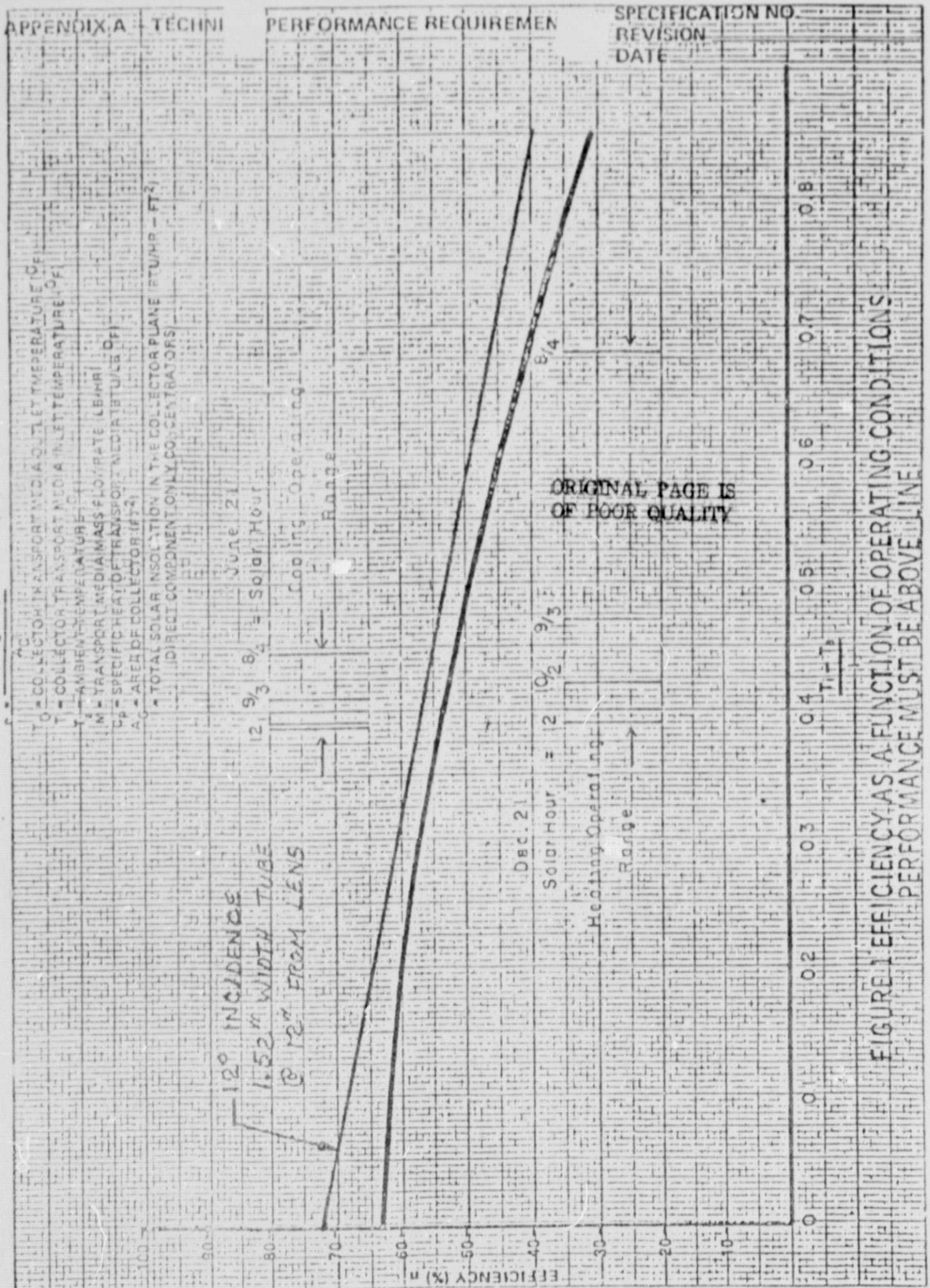
SOURCE LEVEL



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